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Smog—Who Does It Hurt?

What You Need to Know About Ozone and Your Health

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What You Need to Know About Ozone and Your Health

Ozone, when it occurs at ground level, presents a serious air quality problem in many parts of the United States. When inhaled—even at very low levels—ozone can cause a number of respiratory health effects.

In fact, breathing smoggy air can be hazardous because smog contains ozone, a pollutant that can harm our health when there are elevated levels in the air we breathe. This publication will tell you what kinds of health effects ozone can cause, when you should be concerned, and what you can do to avoid dangerous exposures.

What is ozone?

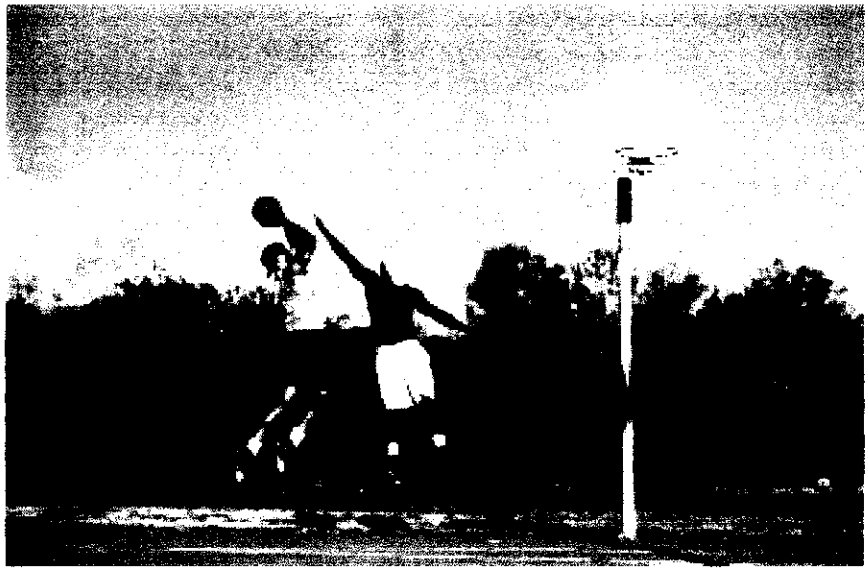
Ozone is an odorless, colorless gas composed of three atoms of oxygen. Ozone occurs both in the Earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found:

- **Good Ozone.** Ozone occurs naturally in the Earth's upper atmosphere—10 to 30 miles above the Earth's surface—where it forms a protective layer that shields us from the sun's harmful ultraviolet rays. This "good" ozone is gradually being destroyed by manmade chemicals. An area where ozone has been most significantly depleted—for example, over the North or South pole—is sometimes called a "hole in the ozone."

- **Bad Ozone.** In the Earth's lower atmosphere, near ground level, ozone is formed when pollutants emitted by cars, power plants, industrial boilers, refineries, chemical plants, and other sources react chemically in the presence of sunlight.

The booklet *Ozone: Good Up High, Bad Nearby*, which can be found on the web at **http://www.epa.gov/oar/oaqps/gooduphigh**, contains additional information about both good and bad ozone.

This publication, *Smog—Who Does It Hurt?*, focuses on bad ozone—that is, ozone that occurs at ground level and can affect the health of people who breathe it.



Children and adults of all ages who are active outdoors are at risk from ozone exposure.

Should I be concerned about exposure to ground-level ozone?

That depends on who you are and how much ozone is in the air. Most people only have to worry about ozone exposure when ground-level concentrations reach high levels. In many U.S. communities, this can happen frequently during the summer months. In general, as ground-level ozone concentrations increase, more and more people experience health effects, the effects become more serious, and more people are admitted to the hospital for respiratory problems. When ozone levels are very high, *everyone* should be concerned about ozone exposure.

Scientists have found that about one out of every three people in the United States is at a higher risk of experiencing ozone-related health effects (see box on page 3). If you are a member of a "sensitive group," you should pay special attention to ozone levels in your area. This publication describes several tools that the U.S. Environmental Protection Agency (EPA), in partnership with State and local agencies, has developed to inform the public about local ozone levels. These tools provide the information you need to decide whether ozone levels on any particular day may be harmful to you. When ozone concentrations reach unhealthy levels, you can take simple precautions (described on page 6 in "What can I do to avoid unhealthy exposure to ozone?") to protect your health.

How might ozone affect my health?

Scientists have been studying the effects of ozone on human health for many years. So far, they have found that ozone can cause several types of short-term health effects in the lungs:

- **Ozone can irritate the respiratory system.** When this happens, you might start coughing, feel an irritation in your throat, and/or experience an uncomfortable sensation in your chest. These symptoms can last for a few hours after ozone exposure and may even become painful.

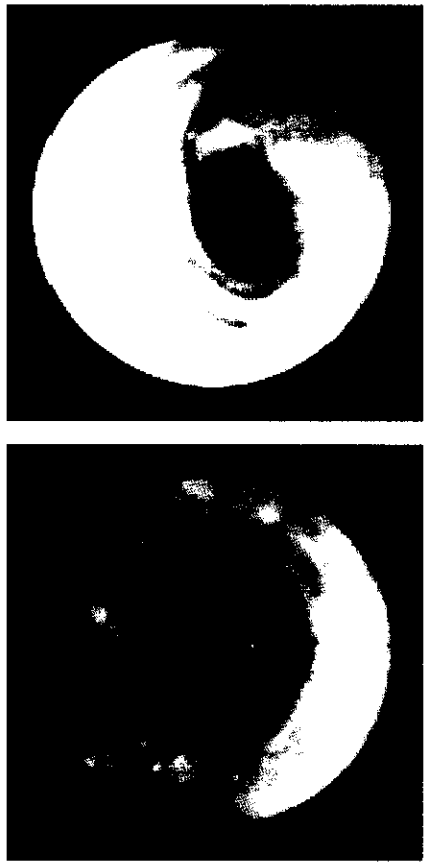
- **Ozone can reduce lung function.** When scientists refer to "lung function," they mean the volume of air that you draw in when you take a full breath and the speed at which you are able to blow it out. Ozone can make it more difficult for you to breathe as deeply and vigorously as you normally would. When this happens, you may notice that breathing starts to feel uncomfortable. If you are exercising or working outdoors, you may notice that you are taking more rapid and shallow breaths than normal. Reduced lung function can be a particular problem for outdoor workers, competitive athletes, and other people who exercise outdoors.

- **Ozone can aggravate asthma.** When ozone levels are high, more asthmatics have asthma attacks that require a doctor's attention or the use of additional medication. One reason this happens is that ozone makes people more sensitive to allergens, which are the most common triggers for asthma attacks. (Allergens come from dust mites, cockroaches, pets, fungus, and pollen.) Also, asthmatics are more severely affected by the reduced lung function and irritation that ozone causes in the respiratory system.

■ **Ozone can inflame and damage the lining of the lung.** Some scientists have compared ozone's effect on the lining of the lung to the effect of sunburn on the skin. Ozone damages the cells that line the air spaces in the lung. Within a few days, the damaged cells are replaced and the old cells are shed—much in the way that skin peels after a sunburn. If this kind of damage occurs repeatedly, the lung may change permanently in a way that could cause long-term health effects and a lower quality of life.

■ **Scientists suspect that ozone may have other effects on people's health.** Ozone may aggravate chronic lung diseases, such as emphysema and bronchitis. Also, studies in animals suggest that ozone may reduce the immune system's ability to fight off bacterial infections in the respiratory system.

Most of these effects are considered to be short-term effects because they eventually cease once the individual is no longer exposed to elevated levels of ozone. However, scientists are concerned that repeated short-term



This photo shows a healthy lung airway (top) and an inflamed lung airway (bottom). Ozone can inflame the lung's lining, and repeated episodes of inflammation may cause permanent changes in the lung.

Who is most at risk from ozone?

Four groups of people, described below, are particularly sensitive to ozone. These groups become sensitive to ozone when they are active outdoors, because physical activity (such as jogging or outdoor work) causes people to breathe faster and more deeply. During activity, ozone penetrates deeper into the parts of the lungs that are more vulnerable to injury. Sensitive groups include:

■ **Children.** Active children are the group at highest risk from ozone exposure. Such children often spend a large part of their summer vacation outdoors, engaged in vigorous activities either in their neighborhood or at summer camp. Children are also more likely to have asthma or other respiratory illnesses. Asthma is the most common chronic disease for children and may be aggravated by ozone exposure.

■ **Adults who are active outdoors.** Healthy adults of all ages who exercise or work vigorously outdoors are considered a "sensitive group" because they have a higher level of exposure to ozone than people who are less active outdoors.

■ **People with respiratory diseases,** such as asthma. There is no evidence that ozone causes asthma or other chronic respiratory disease, but these diseases do make the lungs more vulnerable to the effects of ozone. Thus, individuals with these conditions will generally experience the effects of ozone earlier and at lower levels than less sensitive individuals.

■ **People with unusual susceptibility to ozone.** Scientists don't yet know why, but some healthy people are simply more sensitive to ozone than others. These individuals may experience more health effects from ozone exposure than the average person.

Scientists have studied other groups to find out whether they are at increased risk from ozone. So far there is little evidence to suggest that either the elderly or people with heart disease have heightened sensitivity to ozone. However, like other adults, elderly people will be at higher risk from ozone exposure if they suffer from respiratory disease, are active outdoors, or are unusually susceptible to ozone as described above.

How do scientists know about the health effects of ozone?

A volunteer in an ozone research study breathes into a spirometer—a device that measures lung function.

EPA has gathered a great deal of information about the health effects of ozone. This information comes from a number of sources, including animal research, studies that compare health statistics and ozone levels within communities, and controlled testing of human volunteers to determine how ozone affects lung function. In these studies, volunteers are exposed to ozone in specially designed chambers where their responses can be carefully measured. Volunteers are prescreened in medical examinations to determine their health status, and they are never exposed to ozone levels that exceed those found in major cities on a very smoggy day.

Though our understanding of ozone's effects has increased substantially in recent years, many important questions still remain to be investigated. For example, does repeated short-term exposure to high levels of ozone cause permanent lung damage? Does repeated exposure during childhood to high levels of ozone cause reduced lung function in adults? Scientists are continuing to study these and other questions to gain a better understanding of ozone's effects.

damage from ozone exposure may permanently injure the lung. For example, repeated ozone impacts on the developing lungs of children may lead to reduced lung function as adults. Also, ozone exposure may speed up the decline in lung function that occurs as a natural result of the aging process. Research is underway to help us better understand the possible long-term effects of ozone exposure.

How can I tell if I am being affected by ozone?

Often, people exposed to ozone experience recognizable symptoms, including coughing, irritation in the airways, rapid or shallow breathing, and discomfort when breathing or general discomfort in the chest. People with asthma may experience asthma attacks. When ozone levels are higher than normal, any of these symptoms may indicate that you should minimize the time spent outdoors, or at least reduce your activity level, to protect your health until ozone levels decline.

Ozone damage also can occur without any noticeable signs. Sometimes there are no symptoms, or sometimes they are too subtle to notice. People who live in areas where ozone levels are frequently high may find that their initial symptoms of ozone exposure go away over time—particularly when exposure to high ozone levels continues for several days. This does not mean that they have developed resistance to ozone. In fact, scientists have found that ozone continues to cause lung damage even when the symptoms have disappeared. The best way to protect your health is to find out when ozone levels are elevated in your area and take simple precautions to minimize exposure even when you don't feel obvious symptoms.

How can I find out about ozone levels in my area?

EPA and State and local air agencies have developed a number of tools to provide people with information on local ozone levels, their potential health effects, and suggested activities for reducing ozone exposure.

Air Quality Index. EPA has developed the Air Quality Index, or AQI, (formerly known as the Pollutant Standards Index) for reporting the levels of ozone and other common air pollutants. The index makes it easier for the public to understand the health significance of air pollution levels. Air quality is measured by a nationwide monitoring system that records concentrations of ozone and several other air pollutants at more than a thousand locations across the country.

EPA "translates" the pollutant concentrations to the standard AQI index, which ranges from 0 to 500. The higher the AQI value for a pollutant, the greater the danger. An AQI value of 100 usually corresponds to the national ambient air quality standard (NAAQS) for the pollutant. These standards are established by EPA under the Clean Air Act to protect public health and the environment.

The AQI scale has been divided into distinct categories, each corresponding to a different level of health concern. In the table below, the AQI ranges are shown in the middle column and the associated air quality descriptors are shown in the right column. The left column shows the ozone concentrations, measured in parts per million (ppm), that correspond to each category.

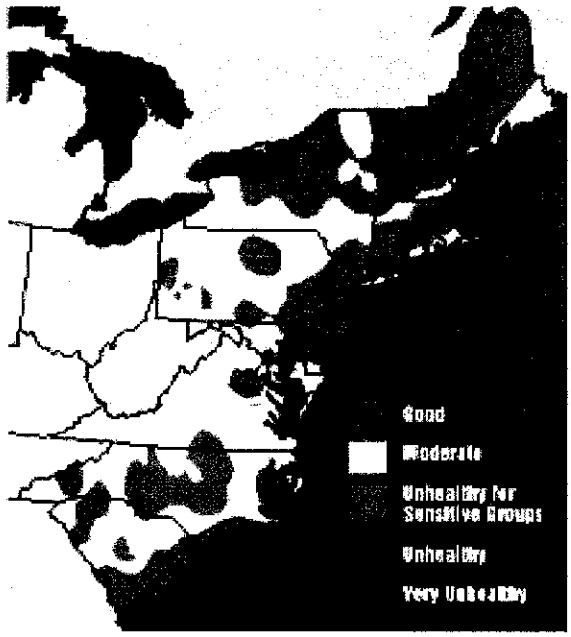
Though the AQI scale extends to 500, levels above 300 rarely occur in the United States. This publication and most other references to the AQI do not list health effects and cautionary statements for levels above 300. If ozone levels above 300 should ever occur, everyone should avoid physical exertion outdoors.

When pollutant levels are high, states are required to report the AQI in large metropolitan areas (populations over 350,000) of the United States. You may see the AQI for ozone reported in your newspaper, or your local television or radio weathercasters may use the AQI to provide information about ozone in your area. Here's the type of report you might hear:

The Air Quality Index today was 160. Air quality was unhealthy due to ozone. Hot, sunny weather and stagnant air caused ozone in Center City to rise to unhealthy levels.

AQI Colors. To make it easier for the public to quickly understand the air quality in their communities, EPA has assigned a specific color to each AQI category. You will see these colors when the AQI is reported in a color format—such as in a color-print newspaper, on television broadcasts, or on your State or local air pollution agency's web site. This color scheme can help you quickly determine whether air pollutants are reaching unhealthy levels in your area. For example, the color orange means that conditions are "unhealthy for sensitive groups," the color red means that conditions are "unhealthy" for everyone, and so on.

Ozone Maps. In many areas of the country, measurements of ozone concentrations are converted into color contours of the AQI categories (green, yellow, orange, red, and purple, shown below) and displayed on a map (see example above) to show ozone levels



This map shows ozone levels in the eastern United States on August 24, 1998. Ozone maps are updated several times daily to show how ozone levels change throughout the day.

Ozone Concentration (ppm) (8-hour average, unless noted)	Air Quality Index Values	Air Quality Descriptor
0.0 to 0.064	0 to 50	Good
0.065 to 0.084	51 to 100	Moderate
0.105 to 0.124	151 to 200	Unhealthy
0.125 (8-hr.) to 0.404 (1-hr.)	201 to 300	Very Unhealthy

In general, when ozone levels are elevated, your chances of being affected by ozone increase the longer you are active outdoors and the more strenuous the activity you engage in.

in the local area. The map is updated throughout the day and shows how ozone builds during hot summer days. In some areas, ozone maps are used to show a forecast of ozone levels for the next day. Once you understand the color scheme, you can use the maps to quickly determine whether ozone concentrations are reaching unhealthy levels in your area. Ozone maps appear on some televised weather broadcasts and are also available from EPA's web site at **http://www.epa.gov/airnow**.

What can I do to avoid unhealthy exposure to ozone?

You can take a number of steps. The chart on page 7 tells you what types of health effects may occur at specific ozone concentrations and what you can do to avoid them. If you are a parent, keep in mind that your children are likely to be at higher risk, particularly if they are active outdoors. You may therefore want to pay special attention to the guidance for sensitive groups.

In general, when ozone levels are elevated, your chances of being affected by ozone increase the longer you are active outdoors and the more strenuous the activity you engage in. Scientific studies show that:

- At ozone levels above 0.12 ppm, heavy outdoor exertion for short periods of time (1 to 3 hours) can increase your risk of experiencing respiratory symptoms and reduced lung function.
- At ozone levels between 0.08 and 0.12 ppm, even moderate outdoor exertion for longer periods of time (4 to 8 hours) can increase your risk of experiencing ozone-related effects.

EPA recommends limiting outdoor activities as ozone levels rise to unhealthy levels. You can limit the

What does exertion have to do with ozone-related health effects?

Exercise and outdoor activities can play an important role in maintaining good health. Physical exertion helps build up strength in the heart and lungs. But exerting yourself outdoors can actually increase your chances of experiencing health effects when ozone concentrations are at unhealthy levels. Why is this true? Think of it this way: Exertion generally causes you to breathe harder and faster. When this happens, more ozone is taken into your lungs, and ozone reaches tissues that are susceptible to injury. Research has shown that respiratory effects are observed at lower ozone concentrations if either the level or duration of exertion is increased. This is why EPA recommends decreasing the level or duration of exertion to avoid ozone health effects.

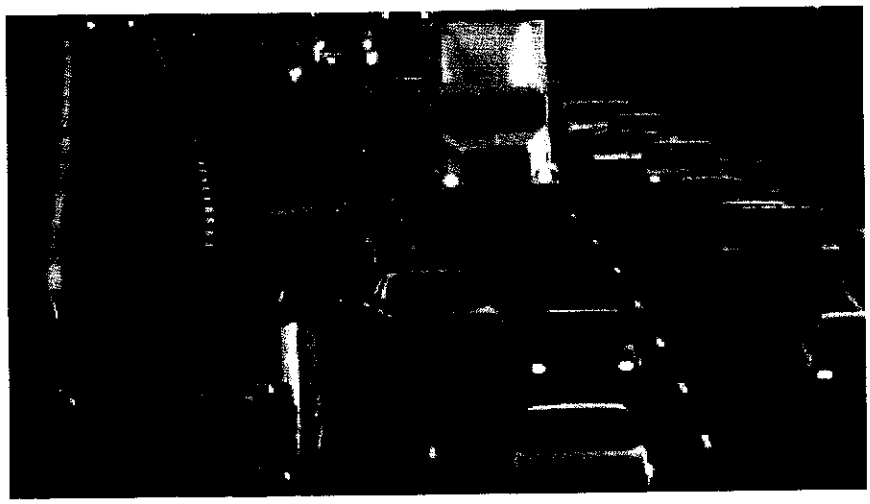
Examples of typical daily activities that involve **moderate exertion** include climbing stairs, light jogging, easy cycling, playing tennis or baseball, and stacking firewood. Outdoor occupational activities such as simple construction work, pushing a wheelbarrow with a load, using a sledgehammer, or digging in your garden, would also involve moderate exertion. Activities that involve **heavy exertion** include vigorous running or cycling, playing basketball or soccer, chopping wood, and heavy manual labor. Because fitness levels vary widely among individuals, what is moderate exertion for one person may be heavy exertion for another. No matter how fit you are, cutting back on the level or duration of exertion when ozone levels are high will help protect you from ozone's harmful effects.

Health Effects and Protective Actions for Specific Ozone Ranges

Ozone Level	Health Effects and Protective Actions
	What are the possible health effects? ■ No health effects are expected.
Moderate	**What are the possible health effects?** ■ Unusually sensitive individuals may experience respiratory effects from prolonged exposure to ozone during outdoor exertion. **What can I do to protect my health?** ■ When ozone levels are in the "moderate" range, consider limiting prolonged outdoor exertion if you are unusually sensitive to ozone.
	What are the possible health effects? ■ If you are a member of a sensitive group,[1] you may experience respiratory symptoms (such as coughing or pain when taking a deep breath) and reduced lung function, which can cause some breathing discomfort. **What can I do to protect my health?** ■ If you are a member of a sensitive group,[1] limit prolonged outdoor exertion. In general, you can protect your health by reducing how long or how strenuously you exert yourself outdoors and by planning outdoor activities when ozone levels are lower (usually in the early morning or evening). ■ You can check with your State air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at **http://www.epa.gov/airnow**.
Very Unhealthy	**What are the possible health effects?** ■ Members of sensitive groups[1] will likely experience increasingly severe respiratory symptoms and impaired breathing. ■ Many healthy people in the general population engaged in moderate exertion will experience some kind of effect. According to EPA estimates, approximately: ■ Half will experience moderately reduced lung function. ■ One-fifth will experience severely reduced lung function. ■ 10 to 15 percent will experience moderate to severe respiratory symptoms (such as aggravated cough and pain when taking a deep breath). ■ People with asthma or other respiratory conditions will be more severely affected, leading some to increase medication usage and seek medical attention at an emergency room or clinic. **What can I do to protect my health?** ■ If you are a member of a sensitive group,[1] avoid outdoor activity altogether. Everyone else—especially children—should limit outdoor exertion and avoid heavy exertion altogether. ■ Check with your State air agency to find out about current or predicted ozone levels in your location. This information on ozone levels is available on the Internet at **http://www.epa.gov/airnow**.

[1]*Members of sensitive groups include children who are active outdoors; adults involved in moderate or strenuous outdoor activities; individuals with respiratory disease, such as asthma; and individuals with unusual susceptibility to ozone.*

The best way to protect your health is to find out when ozone levels are elevated in your area and take simple precautions to minimize exposure—even when you don't feel obvious symptoms.



Motor vehicles are a major contributor to smog.

amount of time you are active outdoors or your activity level. For example, if you're involved in an activity that requires heavy exertion, such as running or heavy manual labor (see box on page 6), you can reduce the time you spend on this activity or substitute another activity that requires less exertion (e.g., go for a walk rather than a jog). In addition, you can plan outdoor activities when ozone levels are lower, usually in the early morning or evening.

You can help reduce ozone levels by walking, biking, carpooling, or using public transportation as an alternative to driving.

What can I do to reduce ozone levels?

Ground-level ozone is created when certain pollutants, known as "ozone precursors," react in heat and sunlight to form ozone. Cars and other vehicles are the largest source of ozone precursors. Other important sources include industrial facilities, power plants, gasoline-powered mowers, and evaporation of cleaners, paints, and other chemicals.

We can all help reduce ozone levels by taking the following steps:

- Drive less. For example, instead of using a car, you may want to walk, use mass transit, or ride a bike.
- Carpool.
- Make sure your car is well-tuned.
- Take care not to spill gasoline when you fill the tank of your car or lawn or recreation equipment.
- Make sure that you tightly seal the lids of chemical products—such as solvents, garden chemicals, or household cleaners—to keep evaporation to a minimum.

For more ideas about what you can do, visit EPA's web site at **http://www.epa.gov/airnow/consumer.html**.